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G1A
G1N
Selected US specifications from IPC sub-classes A61B
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(54) Investigation of the properties of a surface e.g. the elasticity of skin

(57) A device (D) comprises pneumatic means (P) for momentarily altering a zone (A) of the skin (1) and means (E) for assessing the extent of the alteration comprising an emitter (20) of radiation towards the zone (A) and a receiver (21) capable of receiving a proportion of the radiation reflected by the said zone (A). The pneumatic means (P) comprise a nozzle (2) disposed so as to blow a gas along a direction (F) substantially orthogonal to the investigated zone (A). Holding means (M) supports the nozzle (2) at a predetermined distance (*h*) from the surface (3). Deformation of the skin may be plotted for steady or varying gas pressure. The change in colour of the skin may alternatively be measured.

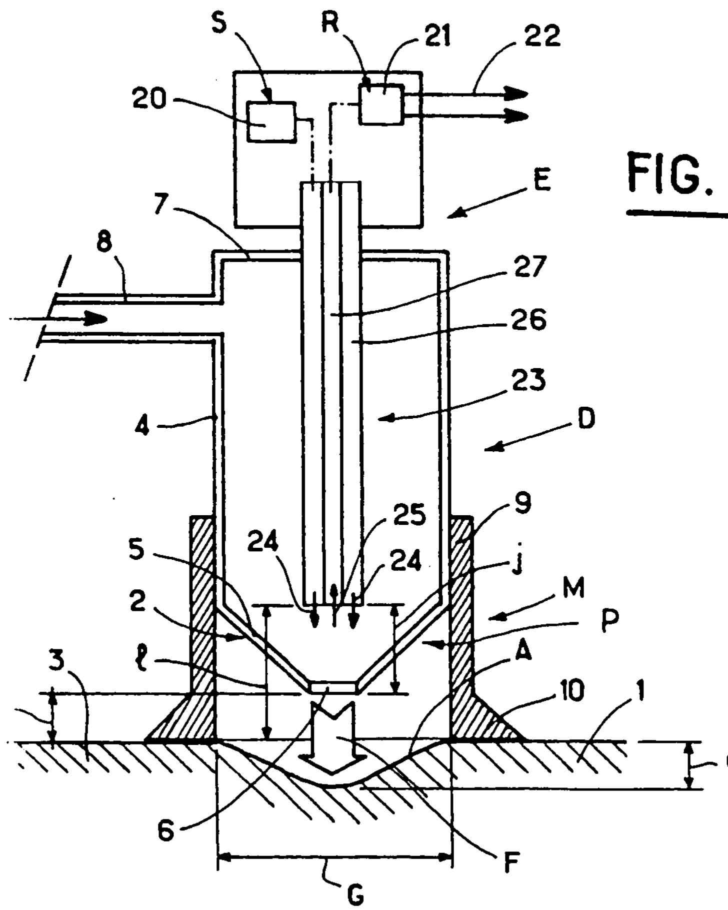

FIG. 2

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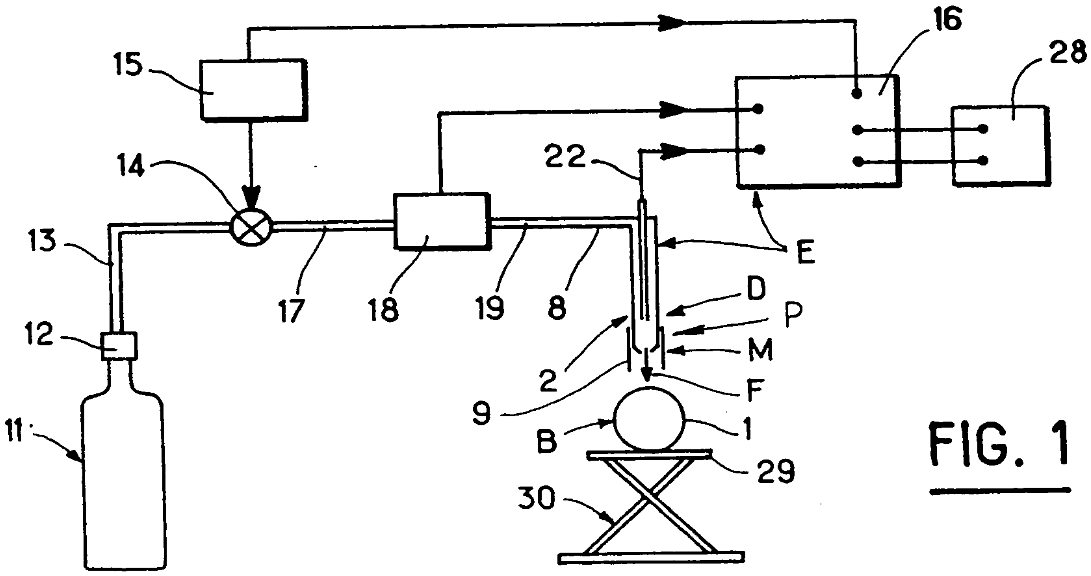
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FIG. 1

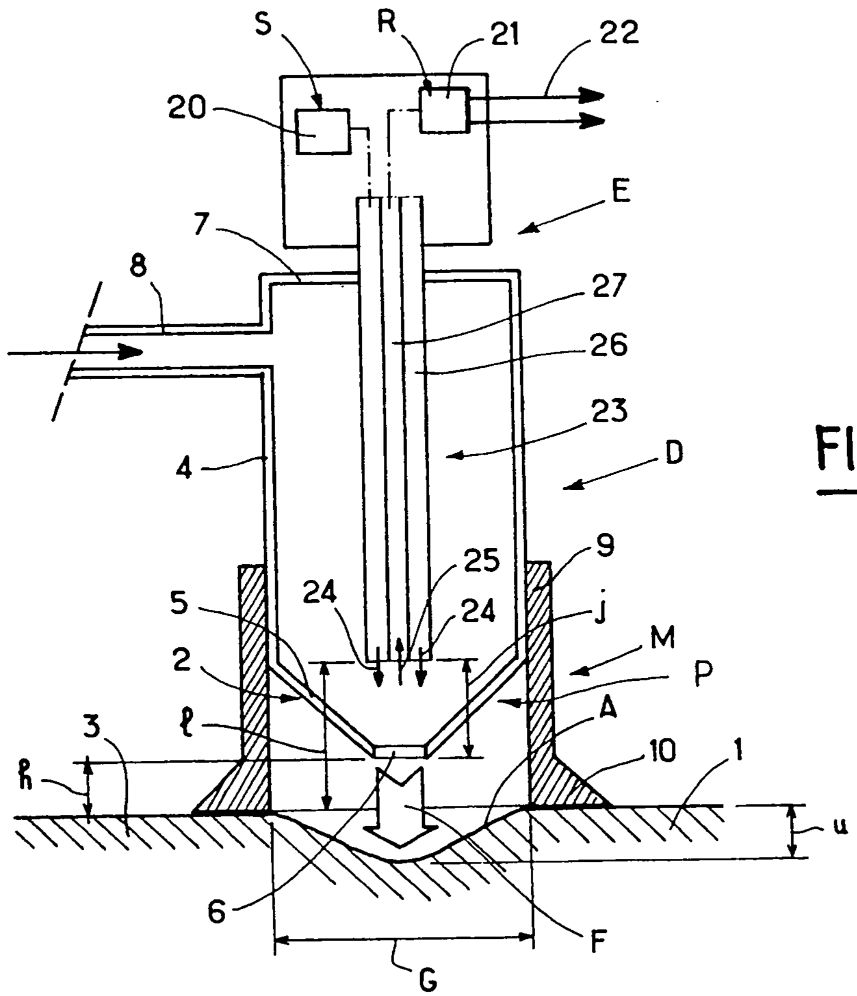
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FIG. 2

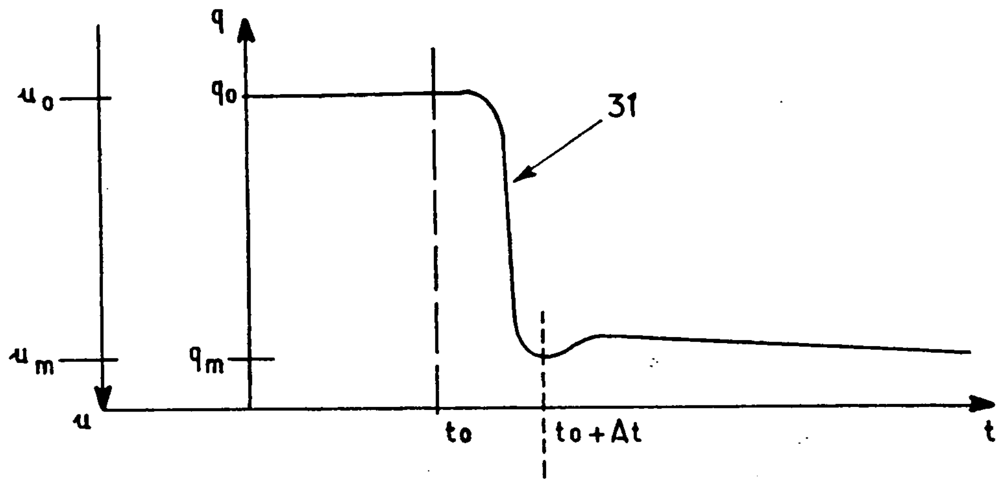

FIG. 3

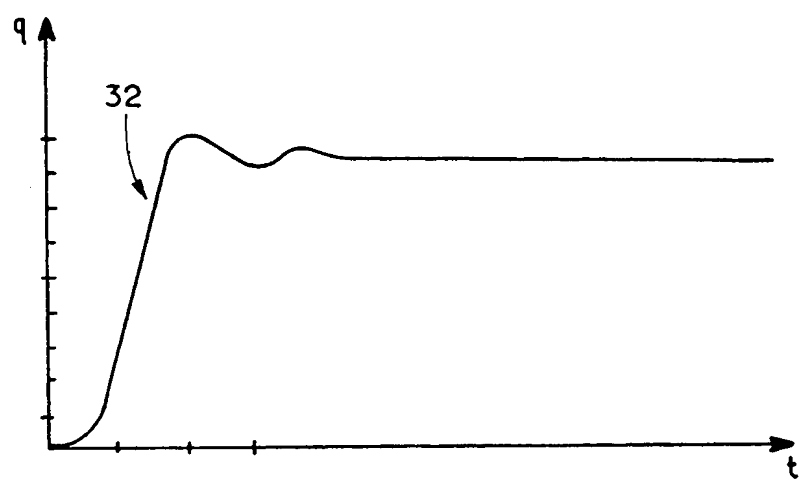

FIG. 4

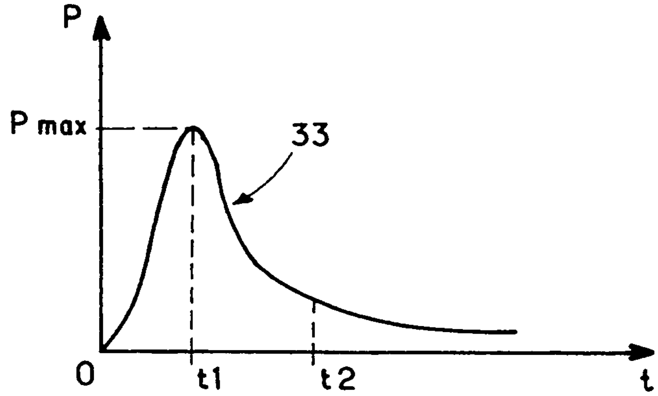

FIG. 5

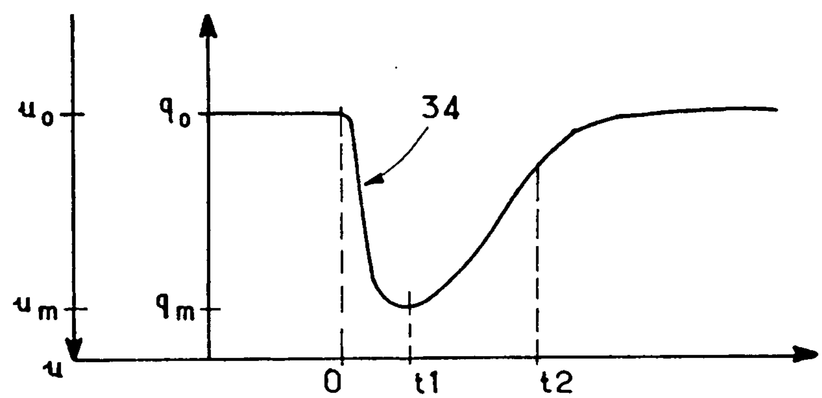

FIG. 6

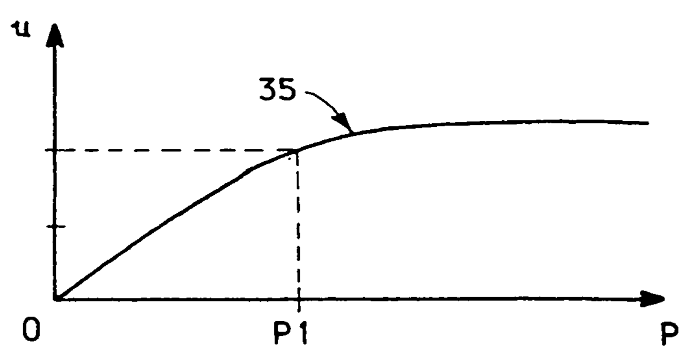

FIG. 7

SPECIFICATION

A device for the investigation of the properties especially of elasticity of a surface in particular of the skin

The invention relates to a device for the investigation of the properties, especially of the elasticity, of a surface, in particular of the skin.

The expression "investigation of the properties of a surface" must be understood in a wide sense; thus in particular when one is concerned with mechanical properties such as elasticity the properties investigated may concern, in the case of the human skin in particular, the surface and the subjacent tissues as a whole.

The devices to which the invention relates are of a type comprising pneumatic means for momentarily altering, in particular deforming, a zone of the surface in determined conditions without material contact other than that of gas and means for assessing the extent of the alteration, in particular of the deformation of the said zone, these assessment means comprising an emitter of radiation towards the zone of the surface investigated and a receiver capable of receiving a proportion of the radiation reflected by the said zone, this reflected proportion depending on the extent of the alteration.

Such devices may make it possible to determine the effect that cosmetics have on the elasticity and the moisture content of the skin and thus to evaluate the efficiency of these products.

A device of the kind defined above is described in the DE-A-3,304,503. This device is relatively bulky, and its operation is not very practical. It has, moreover, a relatively high inertia which has an adverse effect on the speed, the sensitivity and the accuracy of the measurements.

The main object of the invention is to produce devices of the kind defined above such that they meet the various practical requirements better than heretofore and in particular such that their size should be reduced and their operation simpler and faster. It is, moreover, desirable that their inertia should also be reduced, and that the speed as well as the accuracy of the measurements be improved.

According to the invention, there is provided a device for the investigation of the properties of a surface of a zone of skin, comprising:- pneumatic means for momentarily altering a zone of the surface under determined conditions without material contact other than that of the gas; and means for assessing the alteration of the said zone, said assessment means comprising (a) an emitter of radiation towards the zone of the skin surface investigated, (b) a receiver capable of receiving a proportion of the radiation reflected by the said zone, this reflected proportion depending on the extent of said alteration, and (c) supporting means to support the nozzle at a predetermined distance from the surface of the zone under investigation, wherein the pneumatic means for altering the surface comprise a nozzle disposed so as to blow a gas along a direction substantially orthogonal to the investigated zone of the surface.

Generally, the alteration of the surface consists of a deformation of this surface, and the pressure of the gas jet at the orifice opening of the nozzle is of the order of 0.1 to 1.0 bar. The gas under pressure can be simply constituted by compressed air.

Advantageously, the nozzle comprises a body whose axis is substantially orthogonal to the said investigated zone of the surface, the outlet orifice of the nozzle having its centre situated on this axis.

The body of the nozzle can be provided on the side of the gas outlet, and said supporting means may be bearing means which can be adjusted against the surface to be investigated so that the distance of the outlet orifice of the nozzle from the said surface in use of the device can be freely adjusted.

The orifice of the nozzle can have a diameter ranging from 1 mm to 5 mm, and preferably equal to 4 mm. This orifice is situated at a distance of the order of 2 mm from the surface, when the surface is not deformed, that is to say when the gas is not being blown.

Advantageously, the means for the assessment of the extent of the alteration comprise, in a way known per se, an emitter of luminous radiation and a receiver of that proportion of luminous radiation reflected by the zone being investigated, this receiver being capable of converting the quantity of the light received into an electric parameter. These means of assessment thus form an opto-electronic sensor, in particular of the type described and claimed in the FR-A-2,465,213, in the name L'Oreal.

The means of assessment of the extent of the alteration advantageously comprise a part disposed inside the nozzle so that the incident radiation and the radiation reflected by the surface should be identical with or near the axis of the jet blown through the nozzle.

When the assessment means use luminous radiation, provision is preferably made for optical fibres disposed co-axially within the injection nozzle and stopping at a certain distance from the opening through which the gas is blown. The distance between the end of the optical fibres and of the opening of the nozzle can be of the order of 3 mm to 30 mm. A portion of these optical fibres is used for the incident light, whilst the other portion is used to collect the reflected light.

In a manner known per se, the reflected light can be collected by a cylindrical optical

fibre or fibre bundle disposed along the jet axis, whilst the incident light comes from an optical fibre or fibre bundle with an annular cross-section surrounding the above fibre or bundle.

The nozzle can be supplied with gas from a compressed gas cylinder provided with a pressure reducer, connected to the nozzle via a supply ducting fitted with an electrovalve.

The supply ducting for the nozzle is, moreover, advantageously provided with a pressure transducer disposed downline from the electrovalve.

The assessment means preferably comprise an oscilloscope with a digital memory and a recording device.

A relatively large volume, preferably of the order of 20 cm^3, is formed by the ducting between the pressure reducer and the electrovalve to serve as a gas reservoir during a variable pressure measurement.

Apart from the arrangements set out above, other objects and advantages of the invention will be discussed in greater detail below in relation to a particular embodiment described with reference to the attached drawings, but which is in no way restrictive. In the drawings:

FIGURE 1 is a schematic view of an installation as a whole comprising a device in accordance with the invention;

FIGURE 2 is a longitudinal, cross-sectional view of the device on an enlarged scale;

FIGURE 3 is a diagram representing the variations of a parameter in relation to the elasticity of the surface with respect to time as gas is being blown through the nozzle;

FIGURE 4 is a diagram similar to that of Figure 3 but showing the state of affairs when the blowing of pressurised gas through the nozzle ceases;

FIGURE 5 is a diagram illustrating, plotted on the y axis, a variation of pressure of the gas blown through the nozzle with respect to time plotted on the abscissa;

FIGURE 6 is a diagram similar to that of Figure 3 illustrating on the y axis the variations of the parameter depending on the elasticity of the surface, with time plotted on the abscissa, when a pressure pulse corresponding to that of Figure 5 is applied to the nozzle; and

FIGURE 7 is a diagram representing the variations of the above-mentioned parameter depending on the elasticity of the surface (plotted on the ordinate), depending on the pressure of the blown gas plotted on the abscissa.

Referring to the drawings, and in particular to Figures 1 and 2, a device D can be seen for investigating the properties of a surface; in the example contemplated, the device D is more particularly intended for investigating the elasticity of human skin, in particular for investigating the efficiency of cosmetic products.

It is known that the elasticity of tissue diminishes with age and is, moreover, subject to the effect of various parameters, such as the state of health or fatigue of the subject. The object of cosmetic products is, in particular, to increase the elasticity and moisture content of the skin. To evaluate the efficiency of such cosmetic products, it is therefore desirable to be able to measure the elasticity of the skin in vivo before and after the application of the cosmetic products.

The device D comprises pneumatic means P for momentarily altering a zone A (Figure 2) of the skin 1 under given conditions. In the example considered, relating to the investigation of the elasticity of the skin, the alteration of zone A consists in a deformation of this zone, as schematically represented in Figure 2.

The device D also comprises assessment means E which comprise a radiation emitter S directed towards the zone A and a receiver R capable of receiving a proportion of the radiation reflected by skin zone A, this reflected portion depending on the extent of the deformation.

The pneumatic means P comprise a nozzle 2, or similar, capable of blowing a gas, generally compressed air, on to zone A. Provision is made for supporting means M to support the nozzle 2 at a predetermined distance *h* (Figure 2) from the undeformed surface 3.

The nozzle 2 is advantageously disposed so as to blow the gas along a direction represented by an arrow F in Figures 1 and 2, which is substantially orthogonal to the investigated zone A of the surface. This nozzle 2 can comprise a body of revolution 4, especially a cylindrical one, whose end portion 5 facing the skin 1 has a convergent frusto-conical shape ending in the outlet orifice 6 of the nozzle. This orifice 6 can have a diameter ranging from 1 mm to 5 mm, this diameter being preferably at least approximately equal to 4 mm. The distance *h* referred to above corresponds to the distance of the orifice 6 from the surface 3. This distance *h* is advantageously of the order of 2 mm. The body 4 is, on the side remote from its outlet orifice 6, closed by a transverse top 7; a compressed air inlet tube 8 ends in the lateral wall of the nozzle 2, near the top 7.

The supporting means M may be constituted by a sleeve 9 surrounding the end of the nozzle near the outlet orifice 6. This sleeve 9 can be mounted slidably on the body 4 of the nozzle 2 with sufficient grip to allow the two components to be maintained in a relative position which has been selected and adjusted. According to one variant, the sleeve 9 can be screwed on the body 4, the adjustment of the axial position of the sleeve 9 in relation to the body 4 being effected by a rotational motion. At its end adjacent the skin 1, the sleeve 9 comprises an enlarged frusto-conical base 10 intended to rest on the skin

1. Provision is made for openings (not shown) in the wall of the sleeve 9 at the level of the base 10, to allow the compressed air blown by the nozzle 6 to escape from the internal volume of the sleeve 9, after having impacted on the zone A.

A compressed air cylinder 11 (Figure 1) serves to supply the nozzle 2. Provision is made for an adjustable gas pressure reducer 12 on this cylinder 11 to allow a constant gas pressure to be regulated by means of a precision manometer. The preadjusted pressure is, for the operating conditions, preferably less than 1 bar (gauge pressure).

The pressure reducer 12 is connected via a tube 13 to an electrovalve 14 allowing the compressed air outlet to be opened or closed in response to an electric signal provided by an electronic control circuit 15. This control circuit 15 can be used for the automatic actuation, and (if desired) the manual actuation, of the electrovalve 14; the circuit 15 forwards at the same time, a synchronisation signal to an oscilloscope 16 with a digital memory.

The electrovalve 14 is connected, via a tube 17, to a conventional pressure transducer 18, making it possible to control the pressure at the moment when the gas is applied to zone A. This pressure transducer 18 is capable of providing an analogue electric signal which is, in particular, linearly proportional to the pressure. The transducer 18 is connected to the oscilloscope 16 to which it forwards the pressure signal which thus allows the energising signal to be controlled in accordance with time ($\Delta P = f(\Delta t)$).

The output of the transducer 18 is connected via a tube 19 to the inlet tube 8 of the nozzle 2.

The means E for assessing the extent of the deformation comprise an emitter 20 of luminous radiation, in particular of visible light, and a receiver 21 of the proportion of the luminous radiation reflected by the investigated zone A. This receiver 21 is capable of converting the quantity of light received into an electric parameter; this electric parameter is forwarded via a line 22 to the oscilloscope 16. The means of assessment E are advantageously formed by an opto-electronic sensor of the type described in FR-A-2,465,213. These means of assessment E operate, for instance, with non-modulated light.

The means of assessment E comprise a component 23 disposed within the nozzle 2 so that the axis of the incident radiation schematically represented by arrows 24 in Figure 2 is identical with or near to the axis of the jet blown through the nozzle 2. The proportion of the radiation reflected by the surface A towards the receiver 21 is schematically represented by an arrow 25 on Figure 2 which is also near to the axis of the blown jet.

This component 23 comprises optical fibres 26, 27 disposed co-axially with the injection nozzle 2, and stopping at a certain distance j (Figure 2) from the opening 6. This distance can be of the order of 3 mm so that the distance l of the ends (situated in the same transverse plane) of the fibres 26, 27 from the undeformed surface 3, should be substantially equal to 5 mm.

The fibre (or fibre bundle) 26 carries the incident light from the emitter 20 with which it is in optical communication; this fibre 26 has an annular transverse cross-section and is coaxial with the nozzle 2. The fibre 27 carries a proportion of the light reflected by the zone A towards the receiver 21; the optical fibre 27 (or the fibre bundle) has a cylindrical cross-section co-axial with the nozzle 2, and is surrounded by the fibre or fibre bundle 26, which is annular in cross-section. The end of the fibre 27 which is remote from the orifice 6, is in optical communication with the receiver 21. The set of the optical fibres 26, 27 passes through the top 7 of the nozzle 2, sealing means being preferably provided in the vicinity of this passage.

The oscilloscope 15 is connected to a recording device 28.

The dimensions of the device applying the gas pressure to the skin 1 are small; the diameter and the length of the body 4 can be on the small side, especially in view of the fact that the optical fibres 26 and 27 have small dimensions and do not constitute an obstacle to the passing of the compressed air.

The compressed gas stream can thus be applied in a precise manner on to the chosen spot of the skin 1. The conditions for applying the gas jet on to the skin are generally determined in such a way that a jet is obtained having a pressure at the orifice 6 of the order of 0.1 to 1.0 bar, so as to exert a deformation on the surface of the zone A of skin 1 whose diameter G (Figure 2) can vary from 0.5 to 5 cm, and to give rise to a depression depth u (Figure 2) which can vary from 0.5 mm to 2 mm according to the location and property of the skin, or of the individual, chosen. It is to be observed that the internal diameter of the sleeve 9 can be of the order of 5 cm.

The volume V1 of the tube 13, comprised between the pressure reducer 12 and the electrovalve 14, is chosen to be sufficiently ample so as to constitute a reservoir; this volume V1 can be of the order of 20 ml. The volume of the tube 17 is equal to V2 whilst the volume of tube 19 is equal to V3. The mounting is effected in such a way that this volume V3 of the tube 19 should be as small as possible, whilst the volume V1 is much greater than the sum V2 + V3.

In Figure 1, the device D has been represented in the course of application (the supporting sleeve 9 not yet having contacted the skin 1) on the arm B of an individual, this arm resting on a cradle 29 supported by a trestle

stand 30.

This being the case, the functioning and application of the device in accordance with the invention will now be described.

Three types of measurement are possible, that is to say:

measurements with a constant stabilised gas pressure;

measurements with a variable gas pressure (impulse regime);

measurements for the plotting of the pressure/deformation characteristics.

These different types of measurements will be described in turn.

First of all, the measurement effected with a constant stabilised compressed air pressure P_0 will be considered.

The pressure P_0 chosen is preselected by means of the pressure reducer 12, P_0 being less than 1 bar.

The opening of the electrovalve 14 is actuated at time t_0 (see Figure 3). The quantity of light collected by the receiver 21 and converted into an electric voltage q_0 before deformation, exceeds that collected after the deformation of zone A. The minimum electric voltage qm obtained on the receiver 21 is produced at the instant $t_0 + \Delta t$, (Δt = approximately 10 ms). The variation of the electric voltage q with respect to time t is represented by the curve 31.

The deformation u thus varies in the reverse order with the electric voltage *g*; this is the reason why the u values have been plotted on an axis orientated in the opposite direction in Figure 3.

The skin deformation $\Delta u = um—u_0$ corresponds in Figure 3 to the lowering of the electric voltage $\Delta q = q_0\ gm$, provided by the opto-electronic sensor. The parameter of amplitude $q_0—qm$ thus represents the compressibility of the skin under force P_0.

The time interval Δt (equal to 10 ms in the case of Figure 3) between the moment t_0 when the electrovalve 14 is opened and the moment $t_0 + \Delta t$ when the minimum qm occurs, constitutes an evaluation of the visco-elastic property of the skin and of the time during which the pressure variation Δp is established.

As the electrovalve 14 is closed, which is tantamount to cutting the gas flow blown on to zone A, one obtains a curve 32 represented in Figure 4 which is inverse to that of Figure 3. This curve 32 corresponds to the reestablishment curve of the skin surface.

Now the measurements will be considered which are effected with variable pressure, corresponding in some ways to an impulse.

A volume V1 of pressurised gas (compressed air in the example contemplated) is contained in the tube 13 under a given pressure P_0 between the pressure reducer 12 and the electrovalve 14, ahead of the pressure transducer 18. The cylinder 11 is sealed off from tube 13, for instance by the closing of the pressure reducer 12, whilst the pressure P_0 obtains in the tube 13 and hence in the volume V1.

At the time $t = 0$, the opening of the electrovalve 14 is actuated, the volume Vl of compressed air expands and passes through the tube 17 and the tubing 19 to be blown through the orifice 6. The air pressure measured by the transducer 18 during this "impulse" varies with respect to time according to the curve 33 represented in Figure 5. In this Figure, the time is plotted along the x axis (abscissa) whilst the pressure, measured by the transducer 18, is plotted on the y axis (ordinate). The pressure passes through a maximum value P max at the end of a period $t1$, in particular of approximately 10 ms. At the end of a period $t2$, of the order of four times $t1$ (that is to say, substantially 40 ms in the example considered) the (relative) pressure is low and continues to decrease.

The deformation of the zone A of the skin 1 in response to the impulse of the gas under pressure of Figure 5 is represented by the curve 34 of Figure 6. The time is still plotted along the x axis, whilst on the y axis there has been plotted, as in the case of Figure 3, the electric voltage q obtained at the output of receiver 21; on another axis orientated in the opposite direction, there has been plotted the actual deformation corresponding to the u parameter.

At time 0, the deformation is nil and the electric voltage $q0$ is at its maximum. At time $t1$ corresponding to P max ($t1$ being substantially equal to 10 ms in the example contemplated) the deformation is at its maximum and is equal to qm.

The blown gas pressure then decreases in such a way that the deformation also decreases. At time $t2$, the remaining deformation is small. The curve 34 has the shape of an asymmetric V whose point is rounded.

Figure 7 corresponds to the plotting of the characteristic 35 of the deformation u plotted along the y axis in relation to pressure P of the blown gas which is plotted along the x axis. Up to a pressure P1 of the order of 0.3 bar in the envisaged example of the embodiment and in the envisaged application, the variation of the deformation in relation to the pressure is substantially linear.

The curve 35 is established by means of a succession of experiments applying various pressure values.

The device of the invention which is small in size, can be applied to any part of the skin and allows measurements to be effected rapidly and with accuracy, in particular for determining the compressibility, the moisture content, the viscosity and the elasticity of the skin which makes it possible to determine the effect of cosmetic preparations. The location of the zone A of skin being investigated is

determined by the positioning of the sleeve 9 or the guard ring.

It should be observed that the device of the invention makes it possible to investigate a different alteration of the skin apart from a deformation. For instance, one could investigate the change in colour on contact with a given gas blown through the nozzle 2. The alteration would then consist in this change of colour.

CLAIMS

1. A device for the investigation of the properties of a surface of a zone of skin, comprising:pneumatic means for momentarily altering a zone of the surface under determined conditions without material contact other than that of the gas; and means for assessing the alteration of the said zone, said assessment means comprising (a) an emitter of radiation towards the zone of the skin surface investigated, (b) a receiver capable of receiving a proportion of the radiation reflected by the said zone, this reflected proportion depending on the extent of said alteration, and (c) supporting means to support the nozzle at a predetermined distance from the surface of the zone under investigation, wherein the pneumatic means for altering the surface comprise a nozzle disposed so as to blow a gas along a direction substantially orthogonal to the investigated zone of the surface.

2. A device according to claim 1, wherein the alteration of the surface is a deformation of this surface, the pressure of the gas jet at the outlet orifice of the nozzle is of the order of 0.1 to 1.0 bar, and the property being investigated is the elasticity of the skin.

3. A device according to either of the preceding claims, wherein the nozzle comprises a body whose axis is substantially orthogonal to the said zone being investigated, and the outlet orifice of the nozzle has its centre situated on said axis.

4. A device according to any one of the preceding claims, wherein the supporting means comprise means which can be adjusted against the surface to be investigated so that the distance of the outlet orifice of the nozzle from the said surface can be readily adjusted.

5. A device according to claim 4, wherein said supporting means comprise a sleeve surrounding the end of said nozzle near its outlet orifice.

6. A device according to any one of the preceding claims, wherein the nozzle has an orifice with a diameter ranging from 1 mm to 5 mm.

7. A device according to claim 6, wherein the diameter is substantially 4 mm.

8. A device according to any one of the preceding claims, wherein, when the surface is not deformed, the distance of the outlet orifice of the nozzle from the surface is of the order of 2 mm.

9. A device according to any one of the preceding claims, wherein said radiation emitter is an emitter of luminous radiation and said receiver is a receiver for that proportion of the luminous radiation from said emitter which is reflected by the zone being investigated, said receiver being capable of converting the quantity of the light received into an electric parameter.

10. A device according to claim 9, wherein the means of assessment comprise a component disposed within the nozzle so that the incident radiation and the radiation reflected by the surface should be co-axial with the jet blown through the nozzle.

11. A device according to claim 9 or 10, wherein the means of assessment comprise optical fibres disposed co-axially within the injection nozzle and terminating at a certain distance from the opening through which the gas is blown.

12. A device according to claim 11, wherein the distance between the end of the optical fibres and the opening of the nozzle is of the order of 3 to 30 mm.

13. A device according to claim 11 or 12, wherein it comprises one cylindrical optical fibre disposed along the axis of the jet, for taking up the reflected light, and an optical fibre with an annular cross-section surrounding the first-mentioned fibre, for transmitting the incident light.

14. A device according to any one of the preceding claims, wherein the nozzle is supplied from a cylinder of gas under pressure, and wherein a pressure reducer is connected to the nozzle via a supply ducting fitted with an electrovalve.

15. A device according to claim 14, wherein the supply ducting for the nozzle is fitted with a pressure transducer disposed downline from the electrovalve.

16. A device according to claim 14 or 15, wherein a ducting provided between the pressure reducer and the electrovalve has a relatively large volume, in particular of the order of 20 cm³, for serving as a reservoir during a measurement using variable pressure.

17. A device according to any one of the preceding claims, wherein the means of assessment comprise an oscilloscope with a digital memory and a recording device.

18. A device for the investigation of the properties of a surface of skin, such device being constructed and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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